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GSI Water Solutions, Inc.

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# Technical Memorandum

**To:** Jan Palumbo/EPA

**From:** Heidi Blischke/GSI Water Solutions, Inc.
Randy Pratt/GSI Water Solutions, Inc

**Prepared for:** Georgia Baxter/Baxter

**Date:** December 7, 2016

**Re:** **Comments/Discussion Information on the Battelle Optimization Report for the Baxter Arlington Project**

This technical memorandum provides questions/comments and information for discussion regarding the Optimization Support Former J.H. Baxter &Co. Wood Treating Facility Site Arlington, Washington prepared by the Site Characterization and Monitoring Technical Support Center dated September 15, 2016.

## General Comments

We appreciate the review conducted and agree with much of what is presented. Primarily, we agree that more aggressive source remediation will be integral to being able to discontinue the downgradient treatment system within a reasonable timeframe. We believe that the Site is well characterized and that the biotreatment/recirculation pilot study system is effective at reducing downgradient concentrations. Unfortunately, the review was conducted at a time when the system had been operating poorly for several years and PCP concentrations downgradient of the source had started to increase. Vertical gradient and PCP concentrations are presented in conjunction with the system's pumping rate to show the relationship between system operation and groundwater concentrations and gradients. The system has been operating without shutdown since August 2015.

The conceptual model for the Site is that the primary releases occurred in the main treatment area, LNAPL is present in the main treatment area primarily present in the vadose zone, smear zone and at the water table. Numerous borings extended beneath the extent of contamination in the main treatment area which delineate the base of the contamination. The resulting groundwater plume consists primarily of dissolved PCP in groundwater with limited PAHs. After reviewing the Optimization Report, we carefully re-examined the conceptual model and present our conclusions below in comments related to the Optimization Report.

The review was conducted to examine the following questions:

1) Is the Site characterized sufficiently to move forward with the CMS and implement a corrective measure remedy?

2) What is the character and extent of the NAPL?

3) Is the biotreatment/recirculation system effective in reducing downgradient PCP concentrations to below the 1 μg/L criteria in a reasonable timeframe?

We reproduced a large amount of historic data that should assist in our discussions in next week's meeting. We do not anticipate discussion of every figure, but wanted to have the information available should questions arise that can be resolved with existing data. We have taken into account the concerns presented in the report and after a presentation of additional data, present a proposed corrective measure that takes into account many of the aspects presented in the Optimization Report.

## Specific Comments

1. **Page 2. Site History and Operations. Third Paragraph.** Baxter retains property ownership and the responsibility to address *legacy* environmental issues. McFarland is responsible for spills or environmental incidents that occur during their operations and for stormwater management.

2. **Page 3. Site History and Operations. Top of page.** The landfill was capped and closed in the early 1990's. It is regulated under a Closed Landfill Solid Waste permit issued by Snohomish Health District - Solid Waste and Toxics Section. There is a stormwater retention pond in the southwest corner and groundwater monitoring is conducted in accordance with the post-closure requirements in the permit. The Landfill property parcel is 5.83 acres in size and the landfill footprint 4.7 acres. It has been mischaracterized in previous reports as being 7 acres. A Closure Report and Post-Closure Plan for the South Landfill were prepared in 1989 by Sweet Edwards/EMCON.

3. **Page 3. Site History and Operations. Top of page.** The northwestern portion of the Site (Hanner Property) was sold to Yacht Properties. The property has no soil contamination associated with the RCRA project, but does have a groundwater plume beneath the surface of the property. Baxter continues to have access to the monitoring wells for replacing iSOCs, well maintenance, and monitoring. Should other remedial activities be required, access will be provided as appropriate.

4. **Page 3. Site History and Operations. 3rd Paragraph.** Process improvements *were* completed and the primary improvements consisted of:

    a. Containment area for the tank farm

    b. Clean and backfill the Old Thermal Tank (The old Butt Tank)

    c. Installed new pressure Retorts (#2 and #3) with contained tank farm

    d. Installed a new Butt Tank

    e. Contained the Drip Pads and installed a leak detection system

    (Reference: Site Investigation Work Plan J.H. Baxter & Co. Arlington Washington Facility Revision 2, May 2002)

5. **Page 3. Site History and Operations. 3rd Paragraph.** Generally, the operations remained the same using the new equipment; creosote usage was discontinued in 1990. (Reference: Site Investigation Work Plan J.H. Baxter & Co. Arlington Washington Facility Revision 2, May 2002) When Stella-Jones took over the operation and leased the property, they switched to a biodiesel blend of #2 medium aromatic oil for mixing with the dry pentachlorophenol (PCP) to produce a 5% PCP solution used to treat poles. They also discontinued use of the Butt Tank for treatment. (Reference: Georgia Baxter)

6. **Page 7. Previous Environmental Investigations and Actions. 1st Paragraph.** The data from the 1999 PCP Occupation Exposure Study from the direct PCP chemical exposure to workers study showed that workers were exposed to airborne concentrations well below OSHA Standards. (Reference: Site Investigation Work Plan J.H. Baxter & Co. Arlington Washington Facility Revision 2, May 2002)

7. **Page 8. Previous Environmental Investigations and Actions. 1st full paragraph.** While the trench design called for coarse gravel and crushed limestone, when the rehabilitation was conducted in August 2015, it was noted that there were significant amount of fines that had accumulated around the edges of the trench preventing the recirculated groundwater from infiltrating. There were numerous system shut-downs due to high water in the trench that occurred since the system was put into place in January 2008. These shutdowns became more frequent until the system was rehabilitated in August 2015. Originally, the thought was that the system clogged due to iron-reducing bacteria; and an acid wash was unsuccessfully used to attempt to improve operations. The rehabilitation in 2015 involved drilling into the trench to assess the issue and completing 10-inch borings to 20 feet through the infiltration trench backfilled with limestone rock to enhance infiltration capability. A complete assessment of the system operation is provided in Comment #21. See attached photos: Figure 1 Bottom of Trench Contact with Native Soil and Figure 2 Bottom of Trench Contact. These photos are from the August 2015 rehabilitation efforts.

8. **Page 11. Contamination Sources.** The only material placed into the landfill was the wood shavings from peeling logs. No treated materials have been placed in the landfill. The PCP detected in BXS-1 (ranging from 25 μg/L to 95 μg/L) is consistent with the plume originating from the main process area (Figure 3 – a representative shallow/intermediate plume map for PCP). The other downgradient well that is also regularly analyzed for PCP, BXS-2, has had no detections of PCP. Figure 4 shows the time series PCP and Total PAH concentrations in BXS-1 and BXS-2. Total PAHs in BXS-1 and BXS-2 are consistently below 0.2 μg/L.

9. **Page 11. Additional Sources.** While it is possible that there have been undocumented spills or releases at the Site, we believe the results from the groundwater well network coupled with the soil data and groundwater grab samples collected from soil borings demonstrate that no significant spills or releases exist beyond those that were identified in the Site Investigation.

   The primary activities occurred in the main treatment area and the groundwater plume and extensive network of soil borings supports the main process area as the source area. There are a number of wells surrounding the plume (MW-4, MW-14, HCMW-5, MW-10, BXS-2, MW-31, MW-17, MW-18, MW-11, MW-2, HCMW-6, HCMW-7, MW-26, MW-27, MW-35, MW-30, MW-38, and MW-43) that either have never had a detection or had a very low detection of PCP. See the well location map (Figure 5) and the concentration time-series plots (Figures 6 through 22). No treated materials were placed in the untreated pole storage area; and incidental contamination from drips was noted in the treated pole storage area.

Figure 23 shows the historical features including know locations of spills or releases and the wells and soil borings that were advanced prior to the 2005 Site Investigation. There are either borings or a well installed in all locations where spills or releases were identified. Figures 24 through 28 show the results for those locations. The highest surface soil PCP concentration was noted at sample 42 located in the treated wood storage area adjacent to the main treatment area (Figure 24). Figure 25 shows the subsurface data for PCP in soil. The highest concentrations are located at 28-30 feet in the smear zone. There are numerous borings around the perimeter of the main treatment area that contain low or no detection of PCP with borings advance to the smear zone. The following borings were advances without any signs of contamination (no oil, sheen, or odor):

SB-34 drilled to 44 feet below ground surface (ft bgs)
B-1 - 50 ft bgs
SB-5 – 35 ft bgs
SB-13 – 25 ft bgs
SB-17 – 30 ft bgs
SB-7 – 19 ft bgs
SB-22 – 32 ft bgs
MW-1 – 49.5 ft bgs
SB-9 – 28 ft bgs
SB11 and SB-11b – 6 ft bgs
SB-19 – 12 ft bgs
SB-29 – 52 ft bgs
SB-31 – 32 ft bgs
SB-8 – 41.5 ft bgs

Subsurface samples collected from the area surrounding the main treatment area (Figure 26 show very low detections of PCP that would not be expected to result in groundwater contamination. The highest detection was at 27.5 feet in SB-2 with a PCP concentration of 0.69 mg/Kg. Figure 27 present the TPH results in subsurface soils from the main treatment area. There were few detections and these are associated with areas where PCP concentrations were elevated. Figure 28 shows the PCP concentration in groundwater from grab samples from soil borings (collected between 1999 and 2000) and wells collected on October 2000 or January 2001. This shows that the highest concentrations are in the main treatment area with numerous wells surrounding the main treatment area with no detections.

Based on those results, additional data was collected for the Site Investigation Report. These locations and results are shown in Figures 34-41. Surface soil and shallow subsurface soil concentration of PCP are generally low with the highest concentration between 4-6 feet below ground surface at SB 38 in the main processing area at 250J mg/Kg PCP and a detection of 10 mg/Kg in surface soil at SS-09 located west of the main process area. Other surface and subsurface sample concentration were either close to 1 or well below 1 mg/Kg (Figures 29 and 30). Note that the SB-47 to SB-51borings, which were advanced in the area where a spill was reported in 1990, were primarily non-detect for PCP or contained very low estimated detections of PCP with the highest concentration 0.074 mg/Kg. Figure 31 shows the CPOC concentrations between 10 and 20 ft bgs and Figure 32 shows the COPC concentration between 20 and 40 ft bgs. MW-13 shows elevated PCP concentrations between 18 and 34 ft bgs with the 38-40 ft sample showing significantly lower concentrations. SB-63 shows concentrations of PCP between 140 and 250 mg/Kg between 14 and 24 ft bgs with the 30-32 ft sample showing a significantly lower concentration. Of the new borings advance in the main treatment area, no contamination was noted during drilling in the following borings:

SB-62 – drilled to 34 ft bgs
SB-40 – 37 ft bgs
MW-11 – 38 ft bgs
SB-35 – 34 ft bgs
SB-61 – 34 ft bgs
SB-36 – 34 ft bgs
SB-41 – 42 ft bgs
SB-42 – 43 ft bgs
All of these boring were advance a minimum of a few feet below first water. Figure 33 presents the deep results for SB-2D and SB-3D which were advanced to 100 ft bgs. There was no contamination noted in these borings during drilling and concentrations are low to not detected.

Wells MW-10, MW-11 were placed cross gradient from the main treatment area, and MW-14 was installed as an upgradient well. MW12 and MW-13 were placed within the highest concentration area of the main treatment area based on soil borings (see Figures 25 and 32). Wells MW-15 through MW-18 were installed downgradient of the main treatment area based on the groundwater grab results from SB43-SB46 and SB64 and SB65 to capture the main downgradient axis of the PCP plume. SB-64 had a groundwater grab sample collected at 45 feet below ground surface with a PCP concentration of 470 μg/L. MW-15 was place directly downgradient of SB-64 and MW-16 and MW-17 were placed laterally from MW-115. MW-18 was placed further downgradient from MW-15. Figure 34 presents the groundwater concentrations for PCP from these wells and the associated soil borings. Figure 35 presents the groundwater data from the existing wells for July 2004. The axis of the downgradient shallow groundwater plume is well defined by these borings and wells.

Wells MW-22 through MW-37 were installed as part of the Remedial Action Pilot Study Performance Monitoring Plan submitted by Baxter to EPA in September 2007. These wells are shown in Figure 36. Note that the well names were revised from the PMP Plan to wells MW-22 through MW-37. In 2010, it was noted that the plume migrates downward away from the source area. As a result, an investigation was conducted in 2010 where SB-66 through SB-85 were installed and groundwater grab samples collected from multiple depths. Based on this data, monitoring wells MW-38 through MW-43 were installed. Eleven of the borings were advanced to 100 feet below ground surface. The vertical depth where the highest concentrations were detected was generally above the base of the boring bounding the axis of the plume. Figures 37 through 43 present the locations and groundwater results for these borings and wells.

Based on this distribution of soil borings and wells, it appears that the soil contamination and groundwater plume are reasonably well bounded by either lower concentration data or nondetect values.

We believe that some of the interpretation provided in the optimization report is due to the increasing concentrations noted during the recent sampling events. We believe these increases are based on the lack of effectiveness of the bioremediation/recirculation system stemming from the operational issues that occurred between when it was installed in 2008 and its rehabilitation in August 2015 as presented below in comment #12.

10. **Page 18. Distribution of LNAPL.**

    a. **Additional sources:** The report states that soil borings or wells are not located in areas where releases or spills may have occurred. The tar pit was removed and there is a well in the area where the pit was located HCMW-5 (Figure 44). The boring showed no visual signs of contamination and the groundwater at HCMW-5 has been non-detect for PCP. The 1990 spill located adjacent to Former CB 25 has had numerous soil borings (SB-47-SB51; results shown in Figure 30) and groundwater collected from SB-2 (results shown in Figures 24, 26 and 28 for soil and groundwater grab samples. The well log shows that there were no signs of contamination while drilling (Figure 45 – well log for SB-2). The main treatment area has numerous soil borings and wells including the area where the former drainage ditch was located circa 1970-1990. What other sources are referred to in the report that could be missed?

    b. **NAPL density:** PCP was only used in a dry form and mixed with a light mineral oil that consisted of mixture of aromatic and aliphatic hydrocarbons. The density of the oil was 0.92 g/cc. The density of pure PCP is 1.98. The dry PCP was dissolved into the oil and the resulting density was 0.973 g/cc. This is lighter than water and therefore an LNAPL.

    c. **NAPL extent:** While it is true that there is NAPL present between 10 and 40 ft bgs within the main process area, that NAPL appears to be primarily residual in nature and located for the most part above the water table in the vadose zone and at the water table in the smear zone. Figure 46 shows the distribution of residual NAPL. The borings where no visual or olfactory sign of contamination was present during drilling are shown in light gray. The bold borings are where either a sheen or oil was noted. The borings with green labels were drilled below where there were visible signs of contamination. Figures 53-63 present the well logs for borings where oil blebs or droplets were observed. Figures 64-73 present the well logs for boring where sheen or odor was present. Twelve of these borings showing oil or sheen were advanced to a depth below where signs of contamination were noted in the logs and shown on Figure 46. This is the distribution that would be expected of an LNAPL release.

    d. **NAPL Recovery:** MW-12 and MW-13 were installed as LNAPL recovery wells. Wells MW-19 through MW-21 were added as additional NAPL recovery wells in 2007 (Figure 46), however, very little NAPL has been recovered from these wells. In 2005, NAPL recovery was conducted by extraction using a submersible pump and bailers from MW-12 and MW-13 (See Figures 67 and 68). Recovery resulted in little LNAPL re-entering the wells. Therefore, sorbent socks were placed in the wells (MW-12, MW-13, MW-19, MW-20, and MW-21) in March 2006. The total recovery at MW-12 is approximately 8.4 gallons in the last 10 years. Recovery from MW-13 over the past 10 years is 0.75 gallons, and 0.14 gallons were recovered from each MW-19 and MW-21. This results in 9.48 gallons of total NAPL recovery between September 2005 and September 2015, or less than 1 gallon per year (See Figures67-69 from the 2015 SADD Report).

e. **Potential for NAPL Stringers:** Because of the small amount of potentially mobile NAPL in the source area and light nature of the product (LNAPL), we believe that the concentrations of PCP detected in downgradient wells is not indicative of stringers of NAPL that have migrated downgradient but representative of dissolved PCP in groundwater. The extent of NAPL was well characterized in the main treatment area with 46 borings; 18 of which showed no visual signs of contamination, and of the borings showing sheen or oil blebs, 12 were drilled beneath the depth where contamination was noted.

   We believe that fluctuations in groundwater concentrations downgradient of the recirculation system are a function of the system operation rather than the presence of NAPL. The system began clogging shortly after installation with numerous shutdowns followed by slowing of pumping rates. It has only been in the last year that the system has been operating without shutdowns and a steady pumping rate. Figure 70 shows the average monthly pumping rate for the recirculation system and Figure 71 presents a table showing the number of shutdowns and estimated pumping rates.

f. **Data that provides justification that plume is dissolved:**

   i. Product released is LNAPL because only dry PCP was employed at the Site.

   ii. The PCP plume is consistent with the downward gradient at the Site and therefore, consistent with dissolved concentrations moving with groundwater, not a density driven migration. Figures 72 and 73 group wells as to their relationship to the biotreatment pilot study system. These will be helpful for the subsequent figures. Figures 74 and 75 show the vertical gradients for well pairs since January 2008. Both graphs also present the average quarterly pumping rate for the biotreatment/recirculation system. Figure 75 is the same graph as Figure 74 with a smaller vertical gradient scale to be able to see the small upward and downward gradients between well pairs where the gradient is small. Upgradient of the recirculation system, there is a strong downward gradient as shown by the vertical gradient between MW-25 and MW-32. There is only one measurement prior to the system installation (January 2008), which also shows a fairly strong downward gradient of over 0.1 ft/ft. As shown in Figure 79, the downward gradient is stronger when the recirculation system is pumping at higher rates. When the system is pumping above 30-40 gpm, the vertical gradient ranges from 0.3 to 0.4 ft/ft downward. There is a slight upward gradient for the well cluster between the infiltration trench and extraction wells

(MW-3/MW-33) of between 0 and -.0064 ft/ft with few slightly upward gradients. The last few measurements have showed a small downward gradient perhaps reflecting the continuous infiltration of groundwater. Just downgradient of the extraction wells, there is a slight downward gradient between MW-29 and MW-34 and a slight upward gradient between MW-34 and MW-38 when the system is operating. This makes sense with the extraction wells completion within the intermediate zone at a similar depth to MW-34. In the mid-distance wells downgradient of the system (between the shallow and deep wells (MW-15/MW-40), there is a small downward gradient of between 0.0159 and 0.0069 between August 2010 when the deep wells were installed and a year ago. Then the gradient becomes slightly upward. And between the intermediate and deep, there is a downward gradient when the system is pumping slowly and an upward gradient when the system is pumping harder. For the most distal well cluster, there is a slight downward gradient. The plume appears to have a downward gradient of approximately 0.027 between MW-32 at approximately an elevation of 90 feet and MW-42 at an elevation of approximately 58 feet (distance from MW-32 to MW-42 is approximately 1,170 feet). The small downward gradient is consistent with the generally small downward gradient at the Site. The contaminant distribution is reflective of a strong downward gradient near the source area with a smaller downward gradient at the distal end of the plume. Because the plume appears to be migrating with groundwater flow, this suggests that the plume is composed of PCP dissolved in groundwater, not NAPL stringers.

**iii.** Wells downgradient of the recirculation system react to the system operation. If there were NAPL stringer present, one might expect downgradient wells to continue to display elevated concentrations.

11. **Page 18. Lateral Extent of Dissolved PCP Plume.** We agree that the plume is continuous from the source area to the distal portions of the plume. Since the system was installed in 2009, concentrations downgradient of the system generally decreased, then as the system became clogged and pumping rates decreased, concentrations increased until the system was rehabilitated in August 2015. Figures 76-80 show the groundwater PCP concentrations for shallow and intermediate wells upgradient of the infiltration trench, between the infiltration trench and extraction wells, downgradient close to the extraction wells, downgradient mid distance from the extraction wells and downgradient furthest from the extraction wells for the shallow and intermediate zones, respectively. Figures 81-83 show the deep wells close-in, mid-range and long range downgradient of the extraction wells, respectively. The average monthly pumping rate for the recirculation system is presented on each graph. Locations for the wells are shown on Figures 72 and 73 for shallow/intermediate and deep, respectively.

    Wells directly downgradient of the system show a clear correlation with the pumping rates of the system. Since the system has been back up and running when rehabilitated in August 2015, concentrations are decreasing again. Figure 78 shows that a slug of contaminated groundwater was released when the system was clogged (lower pumping rates) reflected by the higher concentrations passing through the system. That is also likely the cause for the rise in downgradient wells even after the system was rehabilitated in August 2015. With a groundwater flow velocity of between 0.4 and 5 feet per day (per the 2005 SI Report), the travel time for groundwater between MW-34 and MW-42 is between 234 and 2,925 days. We suspect that the flow velocity is closer to 3-5 feet per day based on the relatively rapid response in downgradient wells to the treatment system. Prior to installation of the system, it appears that the groundwater plume was in equilibrium with the groundwater system and appeared to be stable. If the system were discontinued, groundwater concentrations would likely return to pre-system start-up concentrations without additional source remediation.

As noted in comment # 12, the plume is sinking at a similar downward vertical gradient as observed between wells at the site. The dissolved PCP in groundwater plume (generally below 1000 μg/L) will not alter the density of the water enough to create a density driven plume. And as discussed in Comment # 12, the NAPL at the Site is well characterized with numerous borings within the main process area that are drilled to depths where contamination was not noted. In addition, the NAPL is LNAPL based on the density of the PCP solution used at the Site. .

There is a fairly strong downward gradient, just upgradient of the infiltration trench MW-25/MW-32). This gradient was already a strong downward gradient prior to the system startup (0.1158 ft/ft). This is likely the reason that there were high concentrations in MW-32 (up to 1,700 μg/L in January 2008) prior to start-up of the recirculation system. PCP concentrations in MW-32 have steadily dropped to where they are regularly below 200 μg/L (Figure 76).

As discussed above in comment #11, there were numerous borings installed where groundwater grab samples were obtained at multiple depths prior to installing additional wells. These groundwater grab samples were used to identify the axis of the plume as well as the appropriate depths for additional wells. With a few exceptions, most of the exploratory borings were advanced to a depth where the highest PCP concentrations were above the lowest groundwater grab sample.

Therefore, we believe that the primary axis of the plume has been identified both laterally and vertically. The plume configuration matches the conceptual model that the plume is moving with groundwater flow and not as a density driven plume.

12. Page 20. **Vapor Intrusion Risks.** Vapor intrusion risks were considered and determined not to be an issue because of the low Henry's law constant for PCP as supported by EPA.

13. Page 21. **Biotreatment/Recirculation System.** As presented in support of groundwater concentration fluctuations downgradient of the biotreatment/recirculation system, it is clear that the system operated between 2008 and 2011 with a reasonably high pumping rate but numerous high level shut downs. Then after 2011, the system became clogged and shut down frequently and rates had to be reduced to keep the system operations. In August 2015, the system was rehabilitation with a number of 20 foot injection borings drilled through the infiltration trench to allow for infiltration. Figures 76-83 show the concentrations plotted against the system pumping rate. These Figures show a clear

effect of when the system is operating versus when pumping rates were erratic and low. Figures 74 and 75 show the vertical gradients in association with the system pumping rate, and again, there is a clear relationship between the operation of the system and vertical gradients (as would be expected). Figure 84 presents a cross section through the axis of the plume from the source area through MW-43. Soil boring data was added to the figure. The area where NAPL is noted on logs is shown. The plume represents a mix between the highest concentrations noted in wells since 2008 and the grab samples from borings. The First Quarter 2015 and Third Quarter 2016 results are also posted for the wells. The PCP extent may not be completely vertically defined, however, concentrations decrease in borings and the highest concentrations appear to be captured well in the center of the plume. In addition, because there is no DNAPL at the Site, one would not expect the plume to be present deeper than groundwater transport driven migration.

And finally, plan view maps of shallow/intermediate PCP concentrations isopleths for prior to system start-up (January 2008), after the system had been operating for 3 years (Fourth Quarter 2011 – November), after the system began to slow (Third Quarter 2012 – August), after the system had not been operating near capacity for 3 years (First Quarter 2015), and after the system had been operating continuously without shut down for a year (September 2016) (Figures 85-89). The difference in concentrations in downgradient wells prior to system start-up and November 2011 are dramatic. This is a period when the system, while experiencing some down time, was generally operating at a high pumping rate.

Table:

| Monitoring well | PCP Concentration in µg/L January 2008 | PCP Concentration in µg/L November 2011 |
|---|---|---|
| MW-37 | 770 | 22 |
| MW-36 | 270 | 59 |
| MW-29 | 1000 | 0.23J |
| MW-34 | 1200 | 2 |

After the system began to be clogged and shut-downs became more frequent and rates were reduced, concentrations increased, especially in the wells closest to the system as shown in the figures and in the table below. The system was operating well up until November 2011, then the rates began to decrease and by February 2015, the system was only pumping from 2 wells with a total extraction rate of about 5 gpm.

| Monitoring well | PCP Concentration in µg/L November 2011 | PCP Concentration in µg/L August 2012 | PCP Concentration in µg/L February 2015 |
|---|---|---|---|
| MW-37 | 22 | 13 | 75 |

| | | | |
|---|---|---|---|
| MW-36 | 59 | 140 | 120 |
| MW-29 | 0.23J | 0.22J | 59 |
| MW-34 | 2 | 12 | 1800 |

After the system had been operating without shut-downs for a year between August 2015 and September 2016, concentrations decreased, with the effects observed in the wells closest to the system followed by the more distal wells, see the table below. It is clear that with proper operation, the biotreatment/recirculation system is working well to reduce concentrations downgradient of the treatment system.

| Monitoring well | PCP Concentration in µg/L February 2015 | PCP Concentration in µg/L September 2016 |
|---|---|---|
| MW-37 | 75 | 9.6 |
| MW-36 | 120 | 21 |
| MW-29 | 59 | <0.5 (or 0.07 MDL) |
| MW-34 | 1800 | 0.24J |

The deep zone (Figures 90-93) shows similar decreases during times when the system is properly functioning and increases when the system was not operating at an optimal rate. The decreases and increases are delayed as would be expected based on travel times.

We believe that by optimizing the system operation, we can achieve the corrective measure objectives (CMOs) for the biotreatment/recirculation system. We believe that with an increase in pumping rate and evaluation of potential amendments to enhance degradation of the PCP, the system will be highly effective at eliminating the downgradient plume and allow the distal plume to naturally attenuate. Because of the timing of the optimization evaluation, it was conducted at a time when the pilot study system was not operating properly and concentrations were increasing. With the data presented in relationship to system operation, it is evident that the system can achieve CMOs.

14. Page 23. LNAPL hydraulic extraction. Based on the information presented in Comment #11 regarding the NAPL presence, we believe that there is minimal mobile NAPL present that can be hydraulically recovered. Therefore, in the proposed source area remedy, we are suggesting an approach that combines hydraulic recovery with biotreatment/recirculation. The recirculation system will increase the gradient between the injection area and extraction wells which will mobilize more oil than is currently mobile under the existing gradients. In addition, a dual phase pump would be placed in MW-12 to hydraulically recover oil.

15. Page 23. LNAPL hydraulic extraction. Based on the information presented in Comment #11 regarding the NAPL presence, we believe that there is minimal mobile NAPL present that can be hydraulically recovered. Therefore, in the proposed source area remedy, we are suggesting an approach that combines hydraulic recovery with biotreatment/recirculation. The recirculation system will increase the gradient between the injection area and extraction wells which will mobilize more oil than is currently mobile under the existing gradients.

16. Page 25. **ISCO.** The cost for the ISCO in 2013 CMS was prior to AMEC conducting the bench scale study. Findings from the bench scale study indicated that chemical oxidant quantities would need to be over four times greater (23 gm/kg versus 5 gm/kg) than had been assumed for the 2013 CMS cost estimate. Furthermore, when including the sodium hydroxide activator, the quantity of material that needs to be injected goes from an estimated amount of 120,000 pounds to 800,000 pounds. Using the bench scale quantity required to remove 50% as proposed in the Optimization Report, the costs for a remedy using ISCO with activated persulfate is $12.4M . This is substantially greater than the 2013 CMS cost estimate of $2.6M for ISCO (Alternative 6). Figure 94 shows the injection point layout proposed in the 2013 CMS. Figure 95 presents the updated remediation cost estimate. Given the substantial quantities of material needing to be injected and the gravel subsurface, push probe equipment would not be appropriate for advancing borings. Therefore, the numerous borings to inject oxidant would need to be advanced using auger, rotary or sonic methods making implementation more costly and increase the amount of soil needing to be disposed offsite. There would be excess oxidant left in the ground that may mobilize metals that presents an implementation risk, beyond the basic risk of handling oxidants. A final observation: The bench testing was conducted by thoroughly mixing the activated persulfate with wet soil resulting in the optimal conditions for degrading the PCP. Injecting the chemical oxidant into the ground will not provide the same degree of mixing with the PCP as provided in the laboratory suggesting that the bench test results overestimate the amount of mass removal that could be expected at the site.

17. Page 24. **Baxter Proposed Optimization Remedy.** We have taken into account the information presented. While we disagree that installing an independent LNAPL Recovery System would be effective, we have combined it with the enhanced biotreatment system. We find that the data shows that the enhanced biotreatment is working well; that ISCO is cost-prohibitive for what would likely provide less than 50% effectiveness. Our proposed corrective measure for the Site is provided below. We believe that we can achieve greater reduction in source area concentration than the 50% that the ISCO will provide at a substantially lower cost and the remedy will be less intrusive.

## Recommended Alternative: Enhanced Biodegradation Recirculation Systems in Source Area and Plume

This alternative uses in situ bioremediation through groundwater recirculation in the source area and in the downgradient plume. In addition, this alternative includes active recovery of LNAPL in the source area and MNA in the plume to provide a comprehensive contaminant containment program. An in situ bioremediation system was installed in the plume in early 2008 and has operated periodically for 8 years (as described in the comments above which show the operation of the system over the past 8 years). Passive LNAPL recovery was implemented in 2008 in the source area wells with consistent recovery occurring in only one well (MW-12). Each of the elements of this alternative is discussed below. The cost estimate (Figure 96) for this alternative is approximately $7M with a present day cost of just under $5M.

**Source area active LNAPL recovery**. Mobile LNAPL is being recovered using sorbent socks in five wells. These wells area MW-1, MW-12, MW-13, MW-19 MW-20, and MW-21. Currently, LNAPL is being removed on the sorbent socks at well MW-12 without any recovery from other wells. To improve the rate of LNAPL recovery, a skimmer pump will be installed into MW-12. The well would be pumped at a low rate, to prevent significant groundwater drawdown and enhance LNAPL flow towards the well, as part of the in situ bioremediation treatment discussed below.

**Source area in situ bioremediation**. Work to date for the bioremediation system operating in the plume demonstrates that the technology is effective at degrading the PCP in the groundwater. This bioremediation system would address NAPL in the vadose zone and the groundwater in the source area. This system would extract groundwater from the source area and inject it back into the vadose zone within the source area. Nutrients would be metered into the recirculating groundwater to promote optimal growth of the groundwater COC degrading bacteria. The recirculating groundwater would be aerated in the well head vault to add oxygen to the groundwater. Figure 97 shows an array of 7 extraction wells and 15 shallow injection points that would provide treatment in the source area. Figure 98 shows a schematic cross section of the proposed system. The system would be constructed to be flush with the ground surface to allow continued operations at the site. Laboratory testing would be conducted to determine the amount and type of nutrients to add for optimal growth of PCP degrading microbes.

**Groundwater plume in situ bioremediation**. This is the existing system that intercepts groundwater immediately downgradient of the main treatment area using groundwater extraction wells. The extraction wells recirculate the groundwater in situ to an aeration/infiltration trench, which mixes the collected groundwater and aerates it to promote in situ biological degradation of groundwater COCs. The water in the trench then infiltrates, creating a recirculation cell to enhance aerobic biodegradation of groundwater COCs. Groundwater flowing from the recirculation cell undergoes additional biodegradation and MNA in the area downgradient from the recirculation cell. Oxygen infusers (iSOCs) deployed in downgradient monitoring wells act to stimulate ongoing aerobic biological activity.

**Monitored Natural Attenuation in the plume.** As discussed in Section 9.1.2, a long-term groundwater monitoring program would be conducted using 31 wells from the existing monitoring well network. This program has been underway since 2008. For cost estimating purposes, it is assumed that in approximately 15 years, the number of monitored wells would be reduced to 10 wells sampled annually. The monitoring program would be evaluated regularly to assess whether it is adequate to monitor the protectiveness and performance of the system.